Management of brain abscess: an overview

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Recent advances in neuroimaging have resulted in a marked decrease in morbidity and death due to brain abscesses. The advent of computed tomography–guided stereotaxy has reduced morbidity in patients with deep-seated abscesses. Empirical therapy is best avoided in the present era, particularly given the availability of stereotactic techniques for aspiration and confirmation of diagnosis. Despite these advances, management of abscesses in patients with cyanotic heart disease and in immunosuppressed patients remains a formidable challenge. Unusual as well as more recently recognized pathogens are being isolated from abscesses in immunosuppressed patients. The authors provide an overview of the management of brain abscesses, highlighting their experience in managing these lesions in patients with cyanotic heart disease, stereotactic management of brain abscesses, and management of abscesses in immunosuppressed patients. (DOI: 10.3171/FOC/2008/24/6/E3)

**KEY WORDS** • brain abscess • cyanotic heart disease • immunosuppression • stereotaxy

**Pathogenesis**

Development of a brain abscess requires inoculation of an organism into the brain parenchyma in an area of devitalized brain tissue or in a region with poor microcirculation, and the lesion evolves from an early cerebritis stage to the stage of organization and capsule formation. Wimm et al. developed a model of experimental brain abscess in rats and demonstrated that abscesses evolve from a stage of cerebritis and massive white matter edema to encapsulation. They observed several similarities between the abscesses in their model and those that occur in humans: 1) abscesses occurred in the white matter or at the junction of gray and white matter, migrating to the ventricle; and 2) the capsule was thickest toward the meninges and thinnest toward the ventricle. The mode of entry of organisms could be by contiguous spread, hematogenous dissemination, or following trauma. The common predisposing causes of a brain abscess are chronic suppurative otitis media, congenital cyanotic heart disease, and paranasal sinusitis. Immunosuppression due to disease or therapy is emerging as an important risk factor for development of brain abscess.

**Microbiological Spectrum**

In the preantibiotic era, the most common organism isolated from a brain abscess was *Staphylococcus aureus*. With the advent of penicillin and improved antibiotic therapy, *Streptococcus* spp have replaced *Staphylococcus* spp as the most common organisms. Based on the site of origin, the organisms would be different. Table 1 shows the distribution of organisms depending on the site of origin of infection. De Louvois et al. isolated streptococci from abscesses of all types and at all sites, whereas *Enterobacteriaceae* and *Bacteroides* spp were isolated from otogenic temporal lobe abscesses, which had mixed cultures. *Streptococcus* spp have been most commonly isolated from cardiogenic abscesses. In neonates, the most common organisms are *Proteus* and *Citrobacter* spp. Anaerobes are one of the most common causative organisms in a brain abscess. Polymicrobial infections are common, indicating the importance of using both aerobic and anaerobic cultures in diagnosis. Occasionally, intracranial tuberculosis as well as fungal infections can present as an abscess. Therefore, cultures for acid-fast bacilli and fungi should be done in all cases. Uncommon organisms reported include *Listeria monocytogenes* and *Burkholderia pseudomallei*.

**Abbreviations used in this paper:** CT = computed tomography; MR = magnetic resonance.
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In children with an open anteri-
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TABLE 1
Likely pathogens in brain abscess
based on predisposing conditions

<table>
<thead>
<tr>
<th>Predisposing Condition</th>
<th>Likely Pathogens</th>
</tr>
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<tbody>
<tr>
<td>otitis media/mastoiditis</td>
<td>streptococci (anaerobic &amp; aerobic), <em>B. fragilis</em>, <em>Enterobacteriaceae</em> spp, <em>S. aureus</em></td>
</tr>
<tr>
<td>paranasal sinusitis</td>
<td>streptococci, <em>Bacteroides</em> spp, <em>Enterobacteriaceae</em> spp, <em>S. aureus</em></td>
</tr>
<tr>
<td>dental infection</td>
<td>streptococci, <em>Fusibacterium</em> spp, <em>Bacteroides</em> spp</td>
</tr>
<tr>
<td>meningitis</td>
<td><em>L. monocytogenes</em>, <em>C. diversus</em></td>
</tr>
<tr>
<td>cyanotic heart disease</td>
<td>streptococci, <em>Haemophilus</em> spp</td>
</tr>
<tr>
<td>bacterial endocarditis</td>
<td><em>S. viridans</em>, <em>Staphylococcus</em> spp, enterococci, <em>Haemophilus</em> spp</td>
</tr>
<tr>
<td>pyogenic lung disease</td>
<td>streptococci, <em>N. asteroides</em>, <em>Actinomyces</em> spp, <em>Bacteroides</em> spp</td>
</tr>
<tr>
<td>T-cell deficiency</td>
<td><em>Toxoplasma gondii</em>, <em>Nocardia</em> spp, <em>L. monocytogenes</em></td>
</tr>
<tr>
<td>trauma</td>
<td><em>S. aureus</em>, <em>Enterobacteriaceae</em> spp</td>
</tr>
</tbody>
</table>

Clinical Presentation

Brain abscess occurs in the younger age groups-usually in the first three decades of life. The most common presentation is that of headache and vomiting due to raised intracranial pressure. Seizures have been reported in up to 50% of cases. Focal neurological deficits related to the site of the abscess may be present, depending on the size of the lesion. Altered sensorium with nuchal rigidity may occur in cases of increased mass effect resulting in herniation, or in cases of intraventricular rupture of brain abscess.

Diagnosis

A lumbar puncture is contraindicated in patients with a suspected brain abscess because it can result in transtentorial or transforaminal herniation and subsequent death. Moreover, analysis of cerebrospinal fluid does not aid in diagnosis of an unruptured brain abscess. A CT scan of the brain obtained after administration of contrast material shows evidence of a ring-enhancing lesion in a well-defined abscess (Fig. 1) and features of cerebral edema in the stage of cerebritis. The rim of a brain abscess is usually thinner than that seen with neoplastic lesions (Fig. 2). It aids in determining the location of the abscess, its size, number, mass effect, and shifts, and the presence of intraventricular rupture. It also provides information with regard to the cause; the paranasal sinuses and mastoids are also imaged concomitantly. Although MR imaging obtained with diffusion weighting may be more sensitive in the differentiation of an abscess from other cystic brain lesions as well as in detection of the cerebritis stage, it may not be useful in an acutely ill patient and we do not recommend routine MR imaging for diagnosis in patients with a suspected brain abscess. In children with an open anterior fontanelle, an ultrasonogram can be used to diagnose an abscess.

The definitive microbiological diagnosis is made by submission of the pus from the abscess for testing with aerobic and anaerobic cultures. Because fungal and tuberculous diseases can present as a brain abscess, pus should be submitted for both acid-fast bacilli and fungal cultures. Pus from a brain abscess should be submitted for immediate microbiological studies because a delay could lead to negative cultures. Screening investigations should be done in all cases to determine the source of the infection.

Treatment

Treatment of a brain abscess involves aspiration of the pus or excision of the abscess, followed by parenteral antibiotic therapy. Empirical medical therapy is best avoided and should be reserved for patients in whom a bacteriological diagnosis has been obtained from a systemic source or who are extremely ill; that is, too ill to undergo any form of intervention. Small abscesses and lesions in the cerebritis stage respond well to medical therapy alone. Multiple abscesses are best treated with aspiration of the largest one, followed by antibiotic therapy, which may be required for a longer duration of up to 3–6 months. Most recent articles recommend aspiration followed by appropriate antibiotic therapy based on sensitivity of the causative organisms. Weekly or biweekly CT

Fig. 1. Axial Gd-enhanced MR image obtained in a 22-year-old man showing a large, multiloculated, ring-enhancing lesion with a thick wall in the left temporal lobe. The patient had a history of chronic discharge from his left ear and underwent cortical mastoidectomy. He developed headache 2 days after the procedure, at which time this MR image was obtained. He underwent craniotomy and excision of the abscess, followed by antibiotic therapy. Culture of the pus showed *P. mirabilis*.

Fig. 2. Axial contrast-enhanced CT scan obtained in a 33-year-old man who was inconsistent in taking his medications for tuberculous lymphadenitis. The scan demonstrates a hypodense right-sided parietal lesion with a thin enhancing capsule. The patient presented with altered sensorium and right hemiparesis of 1-day duration. He underwent excision of the abscess followed by intravenously administered antibiotics. Pus cultures showed non-hemolytic and anaerobic streptococci. Histopathological investigation of the abscess wall showed evidence of an organizing abscess with occasional granulomas, suggesting synchronous tuberculous and pyogenic infection.
Cyanotic Heart Disease and Brain Abscess

Patients with congenital cyanotic heart disease (with a right-to-left shunt) are at risk for developing a brain abscess. Cranio-ventricular drainage and intravenous antibiotics for 1 month, after obtaining 10 days after antibiotic therapy, revealing persistence of the abscess with enhancement along both lateral ventricle walls, indicating ventriculitis. The patient was treated with external ventricular drainage and intravenous antibiotics for 1 month, after which a right ventriculoperitoneal shunt was inserted. The cerebrospinal fluid culture had shown peptostreptococci. She was asymptomatic after 1 year and could undergo surgery for her cardiac anomaly.
cardiopulmonary systems and exhibit a variety of coagulation defects, rendering them poor candidates for general anesthesia. Moreover, these abscesses are often deep seated in location, in proximity to the ventricular system (Fig. 3), and they are often multiple. The treatment of choice in these patients is thus aspiration of the abscess through a bur hole or twist-drill craniotomy performed after induction of local anesthesia. Any coagulopathy, if present, should be corrected before the surgical intervention. In one series, the mortality rate following craniotomy and excision was as high as 71%. Prusty has reported that even with aspiration, nearly 17% of patients can develop cyanotic spells that could lead to life-threatening complications.

The recommended antibiotic therapy is penicillin with chloramphenicol, although there has been a shift toward third-generation cephalosporins in recent years. Takeshita et al. have suggested that intravenous antibiotics be administered for 6 weeks in these patients, with regular CT scans obtained to monitor the size of the abscess. Repeated aspirations may be required. Craniotomy should be restricted to patients with abscesses resistant to antibiotic therapy.

The advent of CT scans and their use in the management of these abscesses has resulted in a fourfold decrease in the mortality rate in patients with brain abscesses secondary to cyanotic heart disease; from 40–60% in the pre-CT era to ~10%. This could be attributed to early detection, availability of image guidance for aspiration (particularly in small lesions), and better radiological follow-up during the course of the antibiotic therapy. Intraventricular rupture of brain abscess has been reported to be a poor prognostic factor in these patients. In our experience, the advent of stereotaxy has aided in avoiding empirical therapy in patients with brain lesions, particularly so in patients with brain abscesses secondary to cyanotic heart disease. Stereotactic intervention can also help in obtaining a histological diagnosis of lesions mimicking a brain abscess in these patients. One of our patients with cyanotic heart disease and a ring-enhancing lesion in the brainstem was treated empirically at another institution with antibiotics, with no clinical or radiological response. A stereotactic biopsy of the brainstem lesion revealed a tuberculosis, which responded to antituberculous drugs.

Role of Stereotaxy in Management of Brain Abscess

Sharma et al. have highlighted the role of minimally invasive procedures like stereotactic aspiration or lavage with endoscopic stereotactic evacuation in the treatment of abscesses, even if the lesions are multiloculated. Several authors have recorded the utility of stereotactic techniques in the management of brain abscesses. There are several advantages of stereotactic aspiration. Only stereotactic aspiration is appropriate for small, deep-seated abscesses or those located in eloquent regions of the brain, because it provides a direct and rapid access to the abscess through a predetermined route. Therefore, it is ideal for management of abscesses in the thalamus, basal ganglia, or brainstem. Stereotactic aspiration also avoids the so-called leukotomy effect that can occur with a freehand aspiration technique. Finally, a biopsy of the wall of the abscess can also be obtained at the same time as the aspiration to confirm the diagnosis in case there is any doubt. Sometimes though, the penetration of a thick abscess wall with the blunt-tipped stereotactic probes can be difficult, and one may fail to enter the abscess. Impedance monitoring can avoid the “false-negative” result.

Kondziolka et al. have reported the use of a technique for drainage of abscesses for which a stereotactically guided catheter is placed in the cavity of abscesses ~3 cm. In their experience, factors associated with initial treatment failure following stereotactic aspiration include inadequate aspiration, lack of catheter drainage of larger abscesses, chronic immunosuppression, and insufficient antibiotic therapy. In almost three fourths of their patients, the lesions were successfully managed with a single stereotactic procedure. Itakura et al. have reported good or excellent outcomes in ~90% of patients in whom external drainage of abscesses is in place for an average of ~2 weeks following stereotactic aspiration.

Management of Brain Abscesses in the Immunocompromised Patient

Immunosuppression can predispose patients to the development of brain abscesses. Cunha has reviewed the pathogenesis of central nervous system infections in immunocompromised patients. Compromised hosts impaired T-lymphocyte or macrophage function are prone to developing infections with intracellular pathogens such as fungi (particularly Aspergillus spp) and bacteria like Nocardia spp. Brain abscesses caused by Aspergillus and Nocardia spp have been reported in immunosuppressed patients. Immunosuppression can result from illnesses like systemic or hematological malignancy or infections like human immunodeficiency virus, or it may...
Management of brain abscess

be iatrogenic and due to long-term steroid medication, chemotherapy for malignancies, or immunosuppressive agents used in patients undergoing organ transplants. These patients are prone to the development of brain abscesses secondary to organisms that may not be seen in immunocompetent individuals, and because of this, empirical therapy in these patients should be avoided. Attention should be directed to obtaining a microbiological diagnosis so that appropriate antibiotic therapy can be initiated without delay. The imaging features of the abscess on CT or MR imaging studies do not help in arriving at a diagnosis of its cause. It is also important to subject the pus obtained from the abscess to microbiological examination for fungal elements and acid-fast bacilli besides the routine aerobic and anaerobic cultures. Arunkumar et al.2 reported a series of 5 renal transplant recipients who developed brain abscesses secondary to chronic immunosuppression and whose lesions were managed with CT-guided stereotactic techniques. Each of their patients had a different causative organism, emphasizing the need for specific microbiological diagnosis in every immunocompromised patient with a brain abscess.

References


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